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important ores, retail prices of cut gems, values of metals and minerals; then follows an admirable glossary in which, however, some of the fundamental terms, such as crystal, mineral and polarize, are not defined with scientific accuracy.

The tables which follow the index are summaries of the descriptions, characters in parallel columns and minerals in order of description.

The book is of convenient size for the pocket and embodies much easily accessible and useful information. In spite, however, of the fact that it is, as explicitly stated, designed for the determination of minerals, its value in the absence of all systematic schemes would seem to be rather to refresh the user's memory as to the characters of known or suspected minerals, than as a guide to the determination of unrecognized material.

A. J. Moses

Analysis of Mixed Paints, Color Pigments and Varnishes. By C. D. Holley, Ph.D., and E. F. Ladd, B.S., Professors of Chemistry, North Dakota Agricultural College. New York, John Wiley & Sons. Pp. 235.

This book presents in a more accessible and considerably enlarged form the results of the work done in connection with the enforcement of the North Dakota paint law. It gives the latest and best methods for the analysis of the substances mentioned in its title, and, what is still more valuable, the composition of these articles as found on the American market.

The method for the analysis of linseed oil, however, is incomplete, no mention being made of the process for detecting fish oil in it with certainty.

Incidentally it furnishes a striking commentary on the honesty and integrity of the American paint and oil trade. The authors' investigations showed "white leads" which contained no lead carbonate and but five per cent. of lead sulphate; other pigments were found which were branded in a manner calculated to mislead. Not content with this sort of fraud, water, in some cases to the extent of twenty-five per cent., was mixed with the paints and these put up in packages which were 10 to 13 per cent. short in weight or measure! The authors have done a real service in showing up such conditions.

The work is one of the best contributions to the literature of these subjects that have appeared, dealing not only with analyses, but also with specifications, and the application and testing of paints on a large scale, and should be in the library of every one having to do with the subjects treated.

A. H. Gill

SPECIAL ARTICLES

SOME CONDITIONS AFFECTING VOLCANIC ERUPTIONS

In the study of such natural phenomena as are difficult to investigate by reason of inaccessibility, or of danger to the observer, it is natural and often advantageous to consider some analogous, but less obscure phenomenon and, from a careful study of this, to deduce the laws which govern the former. A case in point is that of a volcano in eruption which, by its very nature, prohibits close inspection, but with which a certain degree of parallelism is found in the action of geysers. More than thirty years ago Fuchs called attention to the similarity existing between the two, comparing the column of water in the geyser tube to the lava in the interior of a volcano and stating that geysers "ont encore une grande importance en ce sens qu'ils nous permettent de nous faire une idée claire des phénomènes qui produisent les éruptions volcaniques." (K. Fuchs, "Les volcans et les tremblements de terre.") In the light of modern volcanological science, however, this generalization of the term "éruptions volcaniques" will be found too sweeping, for it is clear that the action of a trachytic volcano, whose highly silicious magma is at best in a viscous state, can with difficulty be considered as analogous to that of a geyser where fluidity is the most evident characteristic. A comparative study of the two phenomena should, therefore, be prefaced by the explicit statement that the volcano in consideration is of the basaltic type, with lava which is liquid at the temperature of action, and con-

sequently subject to the laws of hydrostatics. With this understanding let us examine for a moment the points of analogy and of difference between the two.

In the lower portions of the geyser-tube the water becomes heated by conduction above 100° C. Ebullition can not take place because of the pressure of the water above, and the excess of heat represents stored energy—a latent force which will manifest itself upon relief of the pressure due to the above standing water column. This latter may be considered as divided into an indefinite number of zones each having a critical temperature depending on its position, that of the surface layer being 100° C. The column of water is progressively heated from below by conduction and convection until the water of some zone attains its critical temperature; boiling takes place, relieving the pressure on the water just below, which, in its turn, bursts into ebullition, and thus a progressive reactionary movement is set up with a rapidly increasing amplitude of vibration until most of the energy latent in the superheated depths is set free, completing the eruption. The action is often begun by a raising of the water, which, at some zone, is near its critical temperature, into a position of lesser pressure, when boiling will begin and the reactionary process be initiated—in either case it will be noted that it is the rapid diminution of pressure by the act of ebullition which institutes the vibratory process. The reader will here recall that, in the bursting of steam boilers, the action is also thought to be multiple, the too rapid escape of steam from a broken part resulting in the sudden liberation of energy latent in the superheated water, thus completing the explosion.

Let us now consider the action of a basaltic volcano, assuming the central conduit to be filled with liquid magma up to the crater. The lava in the conduit below the crater will be subjected to a pressure increasing proportionately with the depth, and the water and other gases occluded in the magmatic material will, under such conditions of pressure and temperature, be possessed of an enormous latent force of expansion. An upforcing of the lava column or a rapid increase of temperature may, therefore, precipitate an eruption by instituting a reactionary process of gaseous expansion exactly as in the case of the geyser. The greater dimensions of the volcano, together with the density of the magma, will render this reactionary process more gradual than in the geyser; inertia and momentum will prolong the vibratory periods, and days instead of minutes may be required to bring about the culmination. It may, indeed, be questioned if, in many cases, an elevation of the lava column, or an increase in its temperature would be sufficiently sudden to initiate the reactionary process, but this may be brought about in another way. An interesting point of divergence from the geyser lies in the height of the volcanic cone within which the lava may rise to a considerable elevation above the earth's surface. Pressure of the lava column on the walls of the cone aided by explosions from below and the re-fusing power of the magma may fissure the cone and permit of a lateral outflow. If this is sufficiently rapid to considerably reduce the level of the lava, the pressure on the magma below is greatly diminished and gaseous expansion takes place, an immense amount of vapor is set free to do battle with the solid materials (due to collapse consequent to the withdrawal of a large quantity of lava), and a great eruption is thus produced. In my opinion, we need not conclude that the rapid gaseous expansion extends to the greater depth of the volcanic conduit and much less to the fire-pocket itself, where the magma, by reason of pressure, may be in a pasty or quasi-solid condition, but the active expansion would be limited to a zone whose depth will bear a certain relation to the original height of the lava column and the difference of level resulting from the outflow. The greater the difference of level the deeper will be the zone of active expansion and the sum total of energy released. The more *rapidly* the disleveling is produced, the more violent will be the explosive effects, although the total

quantity of vapor expanded may be independent of this rapidity, *providing always that the lateral drainage is sufficiently rapid to produce the difference of level.* For it is precisely this which makes the difference between a catastrophal eruption of this class and one which is merely a phase in the progression of an eruptive period. Terminal or subterminal lava streams, or the sluggish forms of lateral outflows can not produce a material reduction in the level of the lava—the former by reason of their location and the latter because the slow drainage is continually compensated by alimentation from below; there being no rapid diminution of pressure, there is consequently no abnormal expansion.

In considering further the points of divergence between geyser and volcano it would seem that, aside from the obvious dynamic and caloric disproportion—that is, the relative insignificance of the former in size, mechanical power and heat energy—a fundamental difference lies in the relative proportions of water and temperature. In the geyser the heat is moderate while water is abundant and, after an eruption, may freely flow into the central conduit, which it occupies in mass. But in the case of the volcano we may imagine that the water can reach the fire-pocket only by capillary infiltration and under such conditions of temperature and pressure as will cause its intimate union—possibly through complete dissociation—with the heated materials with which it comes in contact, forming thus an incandescent, eruptive magma. And this will be the case whether the temperature results from chemical combination of the water with oxidizable material (Davy), from mechanical friction and compression (Mallet) or from the retained original heat of the earth. The magma will augment in quantity, in temperature and in expansive power with the progressive infiltration of water, and, with its occluded gases will seek a vent at the earth's surface. If there exists, instead, a universal magma with already occluded water gases there will still be the same proportion of water to temperature.

But what is perhaps the most important point of difference between geyser and volcano—and to this all the preceding forms but an introduction—is that in the former, actual eruption is determined and brought about by conditions existing within the geyser itself, while in the latter this is not the case. The geyser is truly automatic, the volcano is not. In studying the development of volcanic eruptions one is irresistibly led to the consideration of modifying and controlling forces acting from without and which may even be extra-terrestrial. It is not denied that, given the progressive delivery of active volcanic material from below, an eruption would in time occur even without external influence, but it is claimed that, under actual conditions, eruption will inevitably be precipitated before such a time. If this is true, the study of such modifying influences becomes of the greatest importance, especially in connection with the foretelling of eruptions, and it is only from a profound conviction of its usefulness that the writer ventures to bring forward at this time an old and abandoned hypothesis—that of the luni-solar influence. I believe that the discredit into which this theory has fallen since the days of Palmieri is due partly to a not unnatural reaction from his somewhat extreme views on the subject and partly to a misunderstanding of the mode of action, the few attempts which have been made to show a correspondence between the lunar phases and volcanic phenomena being rather inconclusive. Riccò, in an interesting pamphlet,[1] gives tables showing, in four cases, a coincidence between luni-solar combinations and the eruptions of Stromboli, but neither the coincidence here nor the lack of it in five remaining cases seems very definite, because the time of the eruptions is merely given as the "date of the beginning of the periods of singular activity." External influence upon earthquakes has been more generally studied, Schmidt having presented[2] a carefully prepared summary of the effect of lunar distance, luni-solar positions,

[1] "Sulla influenza luni-solare nelle eruzioni, del Prof. Riccò."

[2] "Stud. üb. Vulk. u. Erdbeben," Leipzig, 1881.

barometric pressure, time of day, time of year and weather upon earthquakes, but each of these is considered separately, while it is only by combination that they are rendered effective. Falb, in a very studious work rarely quoted,[8] considers the luni-solar combinations with conclusions favorable to their coincidence with seismic movements, but the aggregate conclusions of all who have examined the subject do not form a definite and harmonious result. I believe this to be due in part to the very elaborateness of the methods used in treating an essentially simple subject and to taking into consideration a great number of very slight earthquakes and eruptive phases whose entry into the calculation has led to erroneous conclusions—it is like including the mortality of infants in computing the length of human life. I propose, therefore, in this paper, to make a preliminary examination of the subject as it has developed under my own studies during the past two years.

It will be impossible, however, to enter at this time into an exhaustive study of all the possible manifestations or transformations of energy by which the luni-solar influence may affect terrestrial volcanism—tidal action, atmospheric electric potential, electro-magnetic telluric currents, etc.—but, without excluding these, we may for the present simplify our conception of the influence by considering it as productive of a *gravitational disturbance of the terrestrial mosaic.* Imagine such a body as the earth subjected to the varying attraction of the sun and moon, now on one side of both, now revolving between the two like the armature of a giant dynamo in its field of magnetic force; with the moon in such close proximity as to exert a considerable *difference* in attractive force at the earth's center and at the nearest and farthest peripheral points and with an orbit so elliptical as to vary its distance by a factor of more than one tenth. And then consider that in the crust of this revolving earth sphere there exist volcanoes, which are at times in a condition of potential eruption and rock strata in a condition of stress amounting to potential faulting, and it will readily be seen how small is the power required to touch off these little accumulations of latent energy in proportion to the enormous forces involved. Note that the celestial influence is here considered as being exerted merely in the releasing of stored energy and not as being directly concerned in the accumulation of the latent forces. Note also that we have now cast off the restriction imposed earlier in this paper as to the type of volcano to be considered, all types being affected by the external influence.

Let us now consider in detail that which we have defined as "gravitational disturbance." When the sun and moon are in line with the earth, their combined attraction tends to deform the earth sphere to an ellipse—the tendency is resisted and a condition of stress results. When in quadrature their influence is largely neutralized and these changes, in connection with the earth's diurnal rotation, may be considered as the basis of the gravitational disturbance.

The greatest luni-solar gravitational effect, for these latitudes, will be produced when the sun and moon are at opposite ends of a diameter through the earth's center (opposition) and having a north and south declination respectively of 23° (solstice) and with the moon in perigee. These positions would also tend to produce the greatest ocean tides, but we should avoid considering this influence on the basis of tidal action—it is because of this, in my opinion, that much misunderstanding has arisen. We have not to do with a liquid ocean, where, under luni-solar attraction, a moving wave-form would produce, at the times of maximum effect, very high and very low tides, but we must consider a mosaic globe composed for the most part of solid materials in which the effects, although not of such amplitude as to be visible, will be more powerful and less ephemeral. We may imagine the mean luni-solar effect upon the earth during the several days of each favorable position to be a tendency to positive deformation of the sphere. This will result in a diminution of lateral pressures due to terrestrial gravitation

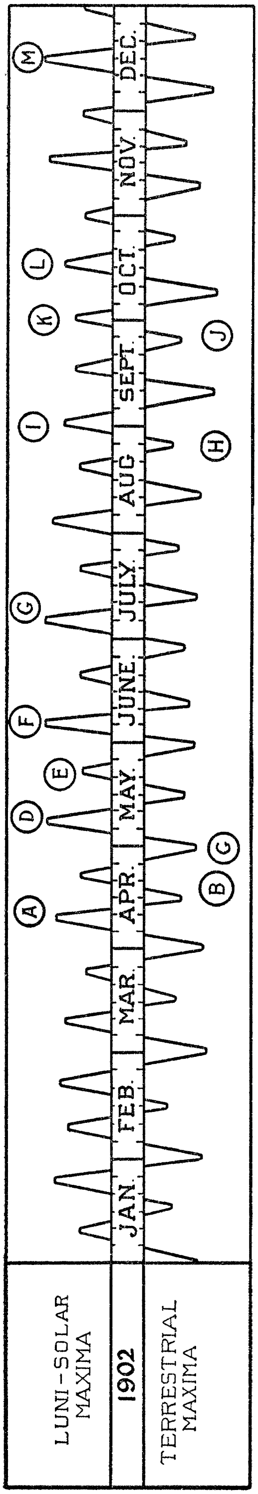
[8] "Grundzüge zu einer Teorie der Erdbeben und Vulkanausbrüche," Rudolf Falb, 1869.

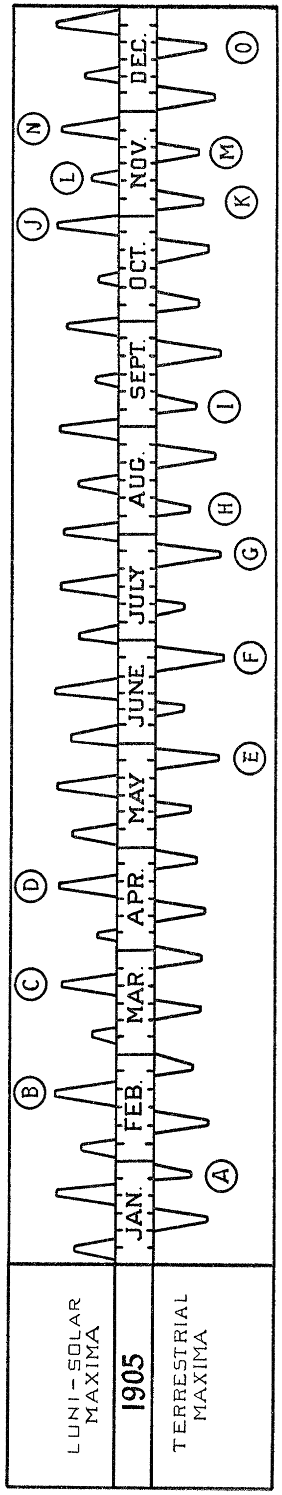
and will be equivalent to a condition of uplift throughout the mass, fissures will tend to widen, and gases in magmatic material will expand. The extreme of this effect will, therefore, tend to favor the emission of gases from volcanic magma, to determine the explosive crises of an eruptive period and to bring about the culmination of great eruptions.

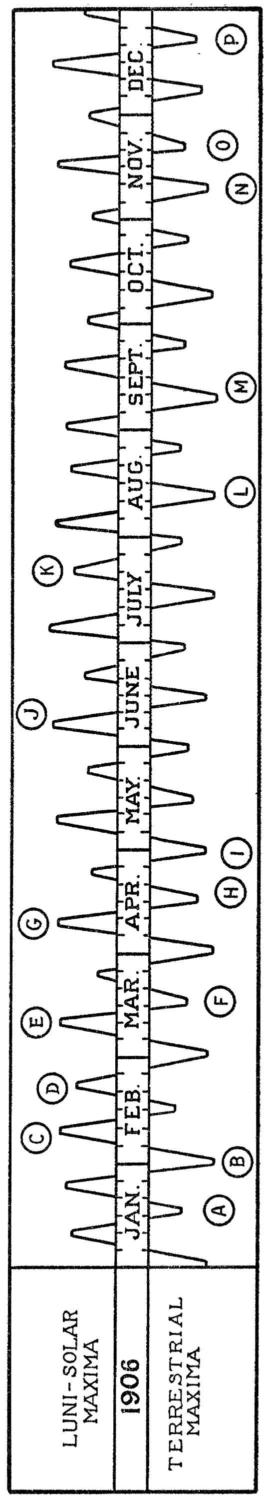
The *minimum* luni-solar influence will be produced when the sun and moon are in quadrature with the earth, with zero declination (equinox) and with the moon in apogee. But it should be noted here—and this is a most important point—that this celestial minimum constitutes a *terrestrial maximum.* The virtual neutralization of the luni-solar distorting power gives full sway to terrestrial re-formation, the results of which, although the converse of those we have just considered, are fully their equal in importance. These periods of maximum terrestrial action will result in a general increase of lateral pressures, tending to the compression of fissures and to the breaking of strata in a condition of stress. The increased pressure on the firepocket and lava-filled fissures of a volcano will force the magma to a higher level, bringing up fresh lava at a higher temperature and tending to cause lava flows; it will readily be seen how slight a compression of a fissure 40 km. in depth would be required to upforce a large amount of lava into the crater of a volcano. Powerful explosive effects may also accompany this phase, being due to the upforcing into the conduit and crater of active, high-temperature lava, and, although of a different character from the paroxysmal gaseous emission of the luni-solar maxima, these explosions may be more effective in rupturing the cone because acting against the pressure of a high lava column; they are, therefore, productive of lava flows and often initiate in this way the progressive reactionary process which will lead up to a catastrophal culmination coinciding with the succeeding luni-solar maximum. As the term *luni-solar minimum* would be confusing as applied to a condition which produces a positive effect, I prefer to designate this phase by the term "terrestrial maximum" as contrasted with "luni-solar maximum." We may, therefore, classify the two orders of maxima with their effects as follows: *Luni-solar maxima* equals *opposition* or *conjunction* plus *perigee* plus *declination,* tending to precipitate explosive crises, paroxysmal emission of gases and the culmination of great eruptions; and *terrestrial maxima* equals *quadrature* plus *apogee* minus *declination,* tending to cause lava flows, rupturing explosive effects and earthquakes. While earthquakes may be caused by either order of maxima, it will in general be found that the great tectonic earthquakes follow, as we should expect, a terrestrial maximum, while those of the volcanic or intervolcanic[4] type may succeed either order of maxima. Earthquakes lag, as a rule, a day or two behind the culmination of the maximum. As the two orders of maxima are complementary, it is obvious that the greatest possible effect will be produced when strong ones occur in proximity, *i. e.,* when a very favorable luni-solar maximum is followed by a very favorable terrestrial maximum, or *vice versa.* We may even suppose, given the general ascensional tendency of the volcanic magma, that a sort of pumping action may take place, a terrestrial maximum forcing lava upwards, a luni-solar maximum holding it there by gaseous expansion, a renewal of the terrestrial effect upforcing more lava, etc. It is possible that such an action may play an important rôle in the formation of new volcanoes, in the production of eccentric eruptions, in the reestablishment of communication between fire-pocket and crater through an obstructed conduit and especially, perhaps, in the eruptive processes of all trachy-andesitic volcanoes with their viscous, highly silicious magma. The compression and elongation stresses due to these alternating effects may also be a potent source of heat.

In plotting a curve of the two orders of maxima I have traced these above and below a medial zone representing an interval be-

[4] Mercalli thus classifies the Calabrian earthquakes, believing that these result from the movements of deep-seated magma.


LUNI-SOLAR MAXIMA
1902
TERRESTRIAL MAXIMA
JAN. FEB. MAR. APR. MAY. JUNE. JULY. AUG. SEPT. OCT. NOV. DEC.
A B C D E F G H I J K L M


LUNI-SOLAR MAXIMA
1905
TERRESTRIAL MAXIMA
JAN. FEB. MAR. APR. MAY. JUNE. JULY. AUG. SEPT. OCT. NOV. DEC.
A B C D E F G H I J K L M N O


LUNI-SOLAR MAXIMA
1906
TERRESTRIAL MAXIMA
JAN. FEB. MAR. APR. MAY. JUNE. JULY. AUG. SEPT. OCT. NOV. DEC.
A B C D E F G H I J K L M N O P

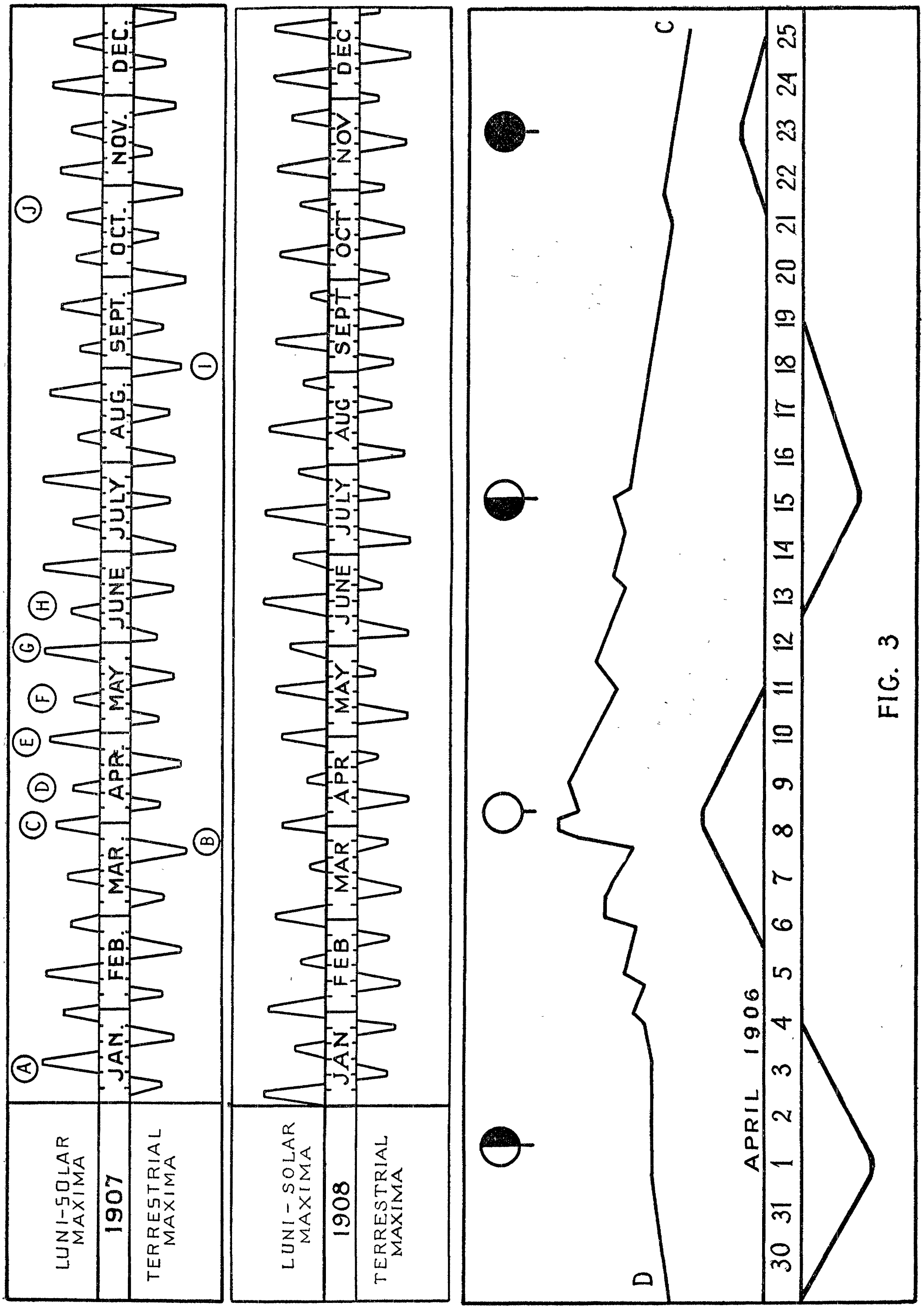

LUNI-SOLAR MAXIMA
1907
TERRESTRIAL MAXIMA
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.
A
B
C
D
E
F
G
H
I
J
LUNI-SOLAR MAXIMA
1908
TERRESTRIAL MAXIMA
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.
APRIL 1906
30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
C
D

FIG. 3

tween conjunction or opposition and quadrature. The values assigned to the various contributory phases are arbitrary, being merely such as have resulted from a brief study of the subject, and as such may be modified by future observations. The effect of conjunction seems to be a little less than that of opposition, but I have given it the same value as the latter; perigee is very powerful. I have used the following values for the lunisolar maxima: Opposition or conjunction 20 points, perigee 20, and half the actual degree value of declination—for example: with moon and sun in opposition, moon in perigee and north and south declination 20°, the result would be: Opposition 20, plus perigee 20, plus declination 10, equals 50. If the moon were in apogee the result would be 20 points less; if the declination were zero the result would be 10 points less, etc.

For the terrestrial maxima, below the medial zone, the values are the same but inversely applied, thus: quadrature 20, apogee 20 and zero declination 10 points. Declination differences in alignment of sun and moon for opposition and conjunction are deducted from the declination values. Difference and supplement in right ascension and the right ascension itself are neglected as being of little importance, and no account has been taken of the earth's perihelion passage nor of the difference in power of sun and moon. The declination values of quadrature are very difficult to assign and it is here that most of the inaccuracy will be found—it is a problem for the astronomer. When any maximum occurs just before or after perigee the point of the maximum is inclined toward the date of perigee. The apogee-perigee values are taken from sinuous curves traced within the medial zone but which do not appear on the finished chart.

On the basis just outlined I have prepared the accompanying curves for 1902, 1905, 1906, 1907 and 1908. In comparing these with some volcanic phenomena occurring in these years I have preferred—in order to avoid any possible personal bias—to quote from the published observations of others, especially of that most accurate observer and indefatigable student of Vesuvius, Prof. G. Mercalli. These observations were made by him without consideration of astronomical influences and were published before I had made his acquaintance. The accompanying curves were made by me according to the above rules and in ignorance of Mercalli's observations.

Referring now to the chart for 1905, I will translate from his "Notizie Vesuviane (anno 1905)," making only such excerpts as relate to the greatest activity during each month.

January: "In the night of the 25th and 26th the explosions took on a character purely *strombolian*[5] with high projection of incandescent material (every four or five minutes)," see (*A*) on chart. The reader will here wish to ask why this did not occur on the date of the first terrestrial maximum, which is more accentuated than (*A*), but it should be noted first, that (*A*) follows a strong *luni-solar* maximum with which it forms a cycle, and it should be remembered also that the active periods we are now considering are comparatively unimportant and may be influenced by local conditions—the interesting and fundamental fact is that even these occur on some maximum of the curve. February: The activity was quite uniform during this month, but the culmination seems to have occurred on the 22d, when the incandescence at the crater—on other days spoken of as "sensible" —is parenthesized as "rather strong." This is close to (*B*). March: "On the 18th and 20th the incandescence was so vivid as to be visible as far as Naples at 6:45 P.M. while it was yet day . . . the new interclosed conelet . . . presented two points separated on the west by a profound depression, where, during the night of the 19th and 20th, I observed permanent incandescence due to a small outflow of lava or at least to the elevation of the

[5] Mercalli's use of this term, now generally adopted, signifies an emission of luminous materials, incandescent fragments and white vapors as contrasted with "vulcanian" which indicates the ejection of non-luminous blocks and bombs with abundant detritus presenting the appearance of black smoke. The terms are descriptive of the *character* and not the force of the explosion.

magma to the edge of the said depression," (*D*). May: In this month occurred the great event of the year—the lava outburst which initiated the long period of lava emission culminating in the catastrophal eruption of April, 1906. Mercalli writes: "In the night of the 25th–26th, after the strongest explosions, the entire surface of the terminal conelet was aglow. The *maximum* occurred on the 26th: by day I saw columns of white vapors without ashes which rose to a thousand meters above the crater; at 5 P.M., although yet day, already there commenced to appear the incandescence of the projected magma: later the ejected scoriæ formed streaks of fire on the external flanks of the cone. At 8:30 P.M. a strong explosion commenced with a very vivid *white light*, certainly due to flames; there followed after a few seconds the usual red color of the bits of incandescent magma. . . . During the day of the 27th the explosions and trembling of the ground were noticed as far as the Hotel Eremo. At about 5:30 P.M. the custodians of the upper station of the funicular railway felt strong earth-shocks. A little later, viz., at 6:15, there opened a first mouth of outflow," etc., (*E*). June: "About the 24th the increase of the outflow was accompanied by a strong explosive activity of the mouth where there was formed a conelet of scoriæ projected from a large eruptive fumarole, (driblet-cone of the English). . . . During the 23d and 24th the explosions were strong but mixed: in the evening they began with dark jets to which quickly succeeded the projection of incandescent scoriæ. On the 25th the explosive activity was very strong until evening (about 7 P.M.) when a portion of the interclosed terminal conelet collapsed," (*F*). July: "Often the lava flowed for a considerable distance covered by preceding lavas, then welled up again from 'pseudo-mouths.' Rapid changes succeeded from the breaking and perhaps the re-fusing of the lava crust at the times of increase. For example, in the early evening of the 29th the principal stream flowed for the most part covered; while instead, a few hours later (between 9 and 12 P.M.), I saw the stream all continuous and very vivid, especially in the lower part," (*G*). August: "The *maximum* occurred on the 8th: then the projectiles reached the edge of the crater of 1872 and the windows and doors of the lower funicular station were rattling," (*H*). September: "The morning of the 8th, between four and five o'clock (the lava) crossed the roadbed of the railway, covering it for about 120 meters, after having demolished in part the large stone wall which the firm of Cook had constructed to protect the lower station of the funicular," (*I*). October: The activity was generally great throughout the month, but I think the culmination is indicated by these words: "After 3 A.M. of the 28th–29th, very violent explosions commenced which shook the two stations, upper and lower, of the funicular." The station master wrote me: "After 3 A.M. a formidable first shock opened up a series of shocks which seemed as though each would dislocate the entire funicular," (*J*). November: . . . "Slight increases (in the lava flow) occurred on the morning of the 6th (*K*) and on the 11th, 17th and 26th (*L*) (*M*) (*N*) . . . the explosions became rather strong on the 5th and 6th," (*K*). December: "After the 16th, a second, more central mouth gave mixed or vulcanian explosions: from the 16th to the 21st and especially on the evening of the 17th a considerable quantity of ash rained as far as the lower station of the funicular. All the while the strombolian action of the other mouth continued," (*O*). In a summing up for the year Mercalli states: "The elevation of the magma to the edge of the crater (19th–20th April) and the explosions accompanied by *flames* (26th of May) signal the two most important maxima of the strombolian dynamism," (*D* and *E*). "In coincidence with the second strombolian maximum there was instituted a sub-terminal outflow of lava," (*E*).

Mention should also be made of the great Calabrian earthquakes on September 8 (*I*) and on October 30 (*J*), and of a volcanic earthquake at Naples on November 26 (*N*).

Mercalli's "Notizie Vesuviane" for 1906 are not yet published. The activity was very great during the first months of the year, with

a marked increase in the lava output on February 2 (B)—chart for 1906—and an explosive maximum on February 7 (C), for an account of which see the New York Sunday *Herald*, April 1, 1906. The great Vesuvius eruption culminated on April 8 (G) and the reader is now referred to Fig. 3 which represents Mercalli's dynamic curve of the eruption —D. C.—to which I have added the astronomical data and the luni-solar and terrestrial maxima curve extended horizontally to fit the scale of Mercalli's diagram. Note how well the progressive reactionary process, of which we have spoken before, is exemplified in the dynamic curve from April 4, working up with increasing amplitude of vibration to the great culmination on the eighth, and note the general correspondence with the maxima curve throughout the entire eruption.

Assuming that we had had this luni-solar and terrestrial maxima curve at the beginning of 1906, it may be well to ask ourselves here if we could have predicted the eruption? Knowing the potential condition of Vesuvius at the time, we should probably have expected the eruption during the maxima combination (C) preceded by (B), but, that failing to be the crisis (although the activity was then very great), I think that we could have predicted it for April 8 (G), preceded as this was by a very strong terrestrial maximum. I have before pointed out that the length of the line joining two different maxima is a measure of the influence. In any event, we could have been morally certain that the eruption would have been precipitated by the strong maxima which follow—in other words, that the summer would not pass without a great eruption.

The San Francisco earthquake of April 18 showed the normal trifling lag behind the terrestrial maximum (H), but at Formosa an earthquake occurred on April 14, and another on March 17 (F). Other severe earthquakes occurred during the year in Iceland, November 8, 9 (N) and November 22 (O); Kopal December 22 (P); Sicily September 13 (M); Calabria January 17 (A) and June 10 (J); Central Asia August 13 (L); India March 10 (E) and July 21 (K); Columbia January 31 (B); West Indies February 21 (D); and Saxony April 28 (I).

On the curve for 1907 the five explosive crises of the great eruption of Stromboli are shown at (D, E, F, G, H), for a full account of which, with dynamic curve, the reader is referred to the *Brooklyn Institute Museum, Science Bulletin*, Vol. 1, No. 7. Mauna Loa was in eruption January 10 (A) and Jaggar reports a violent disruptive explosion of Bogosloff on September 1 (I). Severe earthquakes occurred at Jamaica, January 14 (A), and March 25 (B); in Mexico, April 14 (D); Bitlis, March 31 (C); San Miguel (Azores) April 2 (C); and in Calabria, October 23 (J).

In order to look backward a little I have selected 1902 as being rich in volcanic manifestations and have prepared a curve for that year. The great explosive crises of Pelée occurred on May 8, June 6, July 9, August 30 and December 16. Professor Lacroix writes ("La montagne Pelée et ses éruptions") "Le 8 Mai s'est produit le phénomène terrifiant qui, en quelques minutes, et peut-êtres moins, a anéanti S. Pierre et ses 28,000 habitants" (D). Nuées ardentes 20 Mai (E) et 6 Juin (F). "Une brusque recrudescence paroxysmale le 9 Juillet" (G). "Le 24 Août une secousse de tremblement de terre est ressentie dans toute l'île" (H). "Un grand paroxysme se prepare, il éclate le 30 Août" (I). Nuée ardente 16 Decembre (M).

At St. Vincent: "A la fin d'Avril 1902 ils (earthquakes) augmentèrent, . . . le 29 Avril il ne se produisit pas moins de 18 secousses au Morne Rouge (C)." "Le 7 Mai eut lieu la grande explosion (D)." "Un nouveau paroxysme s'est produit du 15–16 Octobre" (L).

The Pelée paroxysm of July 9 does *not* correspond with the curve. The writer would call special attention to this, the only notable exception in the entire series of events, in the hope that some explanatory observation may be forthcoming which shall give greater precision to the making of future curves.

At Izalco (Salvador) there was a violent eruption September 29 (K).

Heilprin ("Mt. Pelée and the tragedy of Martinique") mentions severe earthquakes in Guatamala, April 18 (*B*) and September 26 (*J*); Finland, April 10–11, and Lake Baikal, April 12 (*A*); Caucasus, April 17 (*B*).

Finally, to turn from the past to the present and future, I have plotted the curve for 1908—a clean page upon which the reader may make his own observations. The Chilapa (Mexico) earthquake and the sudden disappearance of the lake in Oregon will be found to correspond well with the curve. The earthquake registered by the Washington seismograph May 15 and calculated to have occurred at a point about 3,000 miles distant should, if our conclusions are correct, be of volcanic origin, corresponding, as it does, with a luni-solar maximum. From the condition of Etna during 1907 the writer freely predicted an eruption during the present year and, with the aid of the curve, localized it to the spring and summer months. At the time of writing (May) news has come of the initiation of the eruption and it will be interesting to follow its course in connection with the curve and to see if its crises and culminations correspond with the maxima of June 15, July 14 or August 13.

In conclusion the writer desires to state that he fully realizes the crudity and incompleteness at present of this working theory, and his object in bringing it forward at this time, instead of elaborating it by further study and observation, is to stimulate the criticism of others in order that the truth may be the more rapidly advanced. The importance of being able to foreknow the dates in each month when volcanic and seismic manifestations will take place is too obvious to require emphasizing and these data, in connection with research work localized at volcanic and seismic centers, should carry us a long step forward along the line of definitely predicting all such events. During the past two years the writer has often made use of this foreknowledge in planning his visits to volcanoes at interesting times and in absenting himself for preparation work during the intervals of quiet, and it was principally by means of the luni-solar curve that the crisis in the eruption of Stromboli last year was shown to have already occurred when warships had been sent with a view to deporting the 4,000 inhabitants. A resort to this extreme measure was thus rendered unnecessary and this application of our working theory forms a good example of its practical utility.

The present activity of Etna should form a good control and will undoubtedly be of aid in the computing of future curves.

FRANK A. PERRET

THE LOCATION OF EMBRYO-FORMING REGIONS IN THE EGG

THE relation between the visible substances of the egg (nucleus, yolk, pigment, oil, etc.) and the regions of organ-formation has attracted the critical attention of embryologists in recent years. No little diversity of opinion has been expressed as to the rôle played by these substances; whether they represent organ-forming regions, or whether they are only indicia, at most, of more profound changes, is at present the central point of dispute. The separation and stratification of many of these substances by means of the centrifuge has made possible the further analysis of the problem. I wish to put on record here the results of an experiment that bears very directly on the interpretation of the location of organ-forming regions of the egg of *Arbacia*.

As first shown by Lyon, the egg of the sea-urchin may be stratified into four regions by means of the centrifuge. The nucleus is driven into the axis of rotation (secondary egg-axis) and comes to lie near the lighter pole of the egg. Cleavage takes place in most cases at right angles to the stratification. I have been able to demonstrate that the cleavage planes stand in no relation to the original egg axis. Nevertheless, the typical cleavage system generally appears. The primary axis of the embryo, however, bears no fixed relation to the stratification. The fundamental question to settle therefore is what factor determines the location of the embryonic axis.